2006-1197: PROGRESS ON RAISING THE BAR — NEW CE ACCREDITATION CRITERIA

Stephen Ressler, U.S. Military Academy

Colonel Stephen J. Ressler is Professor and Vice Dean for Education at the U.S. Military Academy at West Point, NY. He earned a B.S. degree from USMA in 1979 and M.S. and Ph.D. degrees in Civil Engineering from Lehigh University in 1989 and 1991. He is a registered Professional Engineer in Virginia. He serves as a member of the ASCE Committee on Academic Prerequisites for Professional Practice (CAP^3) and as Vice Chairman of the CAP^3 Accreditation Committee. He is a former Chairman of the ASEE CE Division.

Progress on Raising the Bar—
New Civil Engineering Accreditation Criteria

Introduction

This paper describes new civil engineering accreditation criteria that have been developed in conjunction with implementation of the American Society of Civil Engineers (ASCE) Policy Statement 465. The new criteria include Basic-Level Civil Engineering Program Criteria and Advanced-Level General Criteria, accompanied by a comprehensive draft ASCE Commentary, entitled "Interpretation of the ABET Engineering Criteria for Civil and Similarly Named Programs." All three documents derive directly from ASCE's *Civil Engineering Body of Knowledge for the 21st Century,* which articulates the knowledge, skills, and attitudes required for entry into the civil engineering profession.[1]

These new criteria were drafted in the spring of 2004; however, they have been modified and updated almost continuously since then, as a result of input from across the civil engineering profession. The criteria are best understood in the context of the process by which they were developed and refined. Thus this paper begins with a summary of ASCE Policy Statement 465 and the associated Civil Engineering Body of Knowledge (BOK); it discusses the advantages and limitations inherent in using accreditation criteria as an instrument for fostering implementation of the BOK; it summarizes the development process leading to new draft BOK-compliant accreditation criteria, with emphasis on changes implemented within the past year; and, finally, it provides a description and analysis of the current draft criteria. These criteria are expected to be submitted to ABET in the spring of 2006, published for public review during the subsequent year, and implemented for accreditation visits starting in fall of 2008.

With the forthcoming ABET public review in mind, the ultimate purpose of this paper is to share the new draft criteria with a broader audience and to solicit feedback that will further improve the quality, relevance, and effectiveness of these products.

Background: Policy Statement 465 and the Body of Knowledge

Rapid technological advancement, globalization, and ever-increasing political, social, environmental, and economic constraints are fundamentally changing the practice of civil engineering today. Yet many academic institutions are ill-equipped to respond to these challenges, because of severe credit hour limitations that have been imposed on the four-year bachelor's degree in recent years. Consequently, the bachelor's degree is becoming increasingly inadequate as formal academic preparation for the professional practice of civil engineering.

In response to this situation, the American Society of Civil Engineers (ASCE) Board of Direction adopted Policy Statement 465 in October 1998. This initial version of the policy stated that the Society "supports the concept of the master's degree as the First Professional Degree for the practice of civil engineering at the professional level." As the strategy for achieving this vision developed, it became apparent that the policy should more broadly address the academic

prerequisites for professional practice and licensure, rather than focusing only on the attainment of a specific academic degree. Hence, in October 2001, the ASCE Board adopted a modified version of Policy Statement 465, indicating that ASCE "supports the concept of the master's degree or equivalent as a prerequisite for licensure and the practice of civil engineering at the professional level."

Charged with implementing Policy Statement 465, the ASCE Committee on Academic Prerequisites for Professional Practice (CAP[3]) began by considering the three fundamental characteristics of a profession—an ethic of professional service, a professional organization, and a specialized body of knowledge.[2] The committee's analysis of the civil engineering profession suggested that, of these three characteristics, only the first two were adequately defined. Thus began a broad-based effort to define and articulate the Civil Engineering Body of Knowledge. In January 2004 this effort came to fruition with ASCE's publication of *Civil Engineering Body of Knowledge for the 21st Century*—a report describing the knowledge, skills, and attitudes necessary for entry into the practice of civil engineering at the professional level.

This report describes the Civil Engineering Body of Knowledge (BOK) in terms of fifteen outcomes, the first eleven of which correspond nominally to ABET Criteria 3(a) through 3(k).[3] Outcome 12 describes a requirement for knowledge in a specialized area related to civil engineering; and Outcomes 13, 14, and 15 require understanding of professional practice topics such as management, business, public policy and administration, and leadership.

The fifteen outcomes of the BOK reflect five major areas of emphasis:

- Fundamentals of math, science, and engineering science
- Technical breadth
- Breadth in the humanities and social sciences
- Technical depth
- Professional practice breadth

The association between these "big picture" areas of emphasis and the fifteen BOK outcomes is illustrated in Figure 1 below.

In October 2004, the ASCE Board reinforced the importance of the BOK by modifying the wording of Policy Statement 465 as follows:

> The American Society of Civil Engineers supports the attainment of a Body of Knowledge for entry into the practice of civil engineering at the professional level. This would be accomplished through the adoption of appropriate engineering education and experience requirements as a prerequisite for licensure.[4]

Now that the BOK has been formally defined and endorsed in ASCE policy, its implementation is proceeding along four parallel, coordinated paths—(1) accreditation, (2) curriculum development, (3) licensure, and (4) fulfillment and validation. Each path is the responsibility of a constituent committee of CAP[3]. The development and implementation of BOK-compliant

accreditation criteria is the responsibility of the CAP[3] Accreditation Committee—and is the subject of this paper.

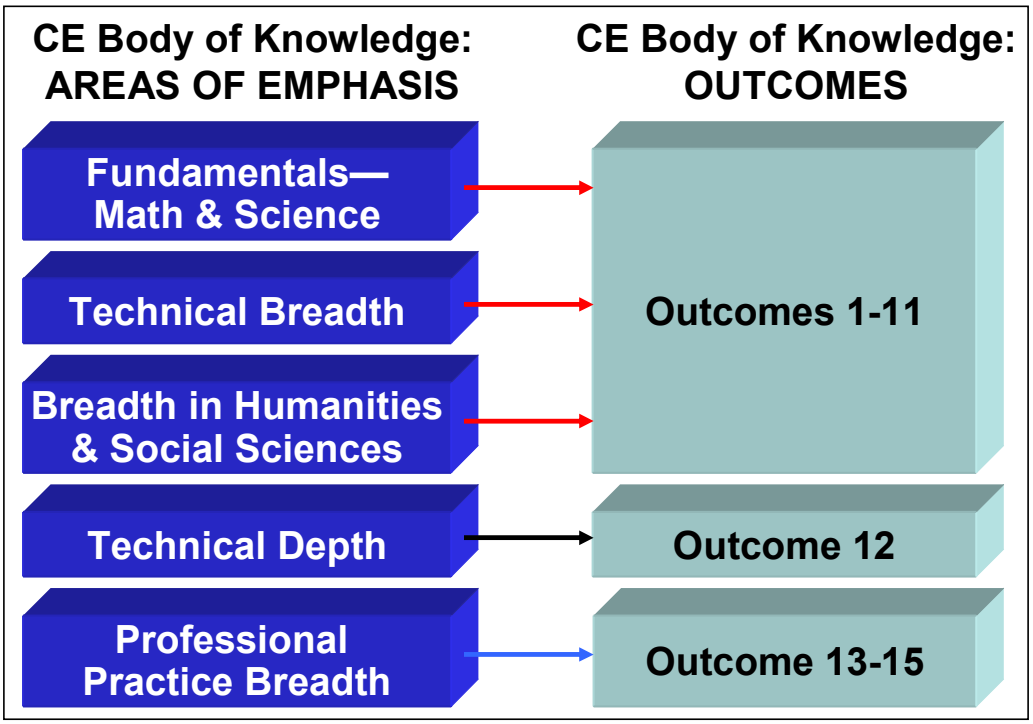

Figure 1. Association between BOK areas of emphasis and BOK Outcomes.

Accreditation Criteria as an Instrument for BOK Implementation

In fulfilling its charge from CAP[3], the Accreditation Committee's ultimate goal is to foster the design, development, and implementation of BOK-compliant curricula in every ABET-accredited civil engineering program in the U.S.

The committee's work is founded upon the assumption that the ABET accreditation criteria constitute the only instrument that can effectively foster broad and reasonably consistent implementation of the BOK. Accreditation criteria can provide a powerful stimulus for curricular change—as demonstrated by the recent study, "Engineering Change," conducted by the Penn State Center for the Study of Higher Education.[5] Furthermore, if the principal elements of the BOK are embedded in accreditation criteria, then the accreditation process can be used effectively as a mechanism for validating BOK fulfillment. In the absence of such a mechanism, BOK validation would require a substantial bureaucratic infrastructure that currently does not exist.

Given this assumption, CAP[3] has proposed that civil engineers should be able to fulfill the Civil Engineering Body of Knowledge by following either of two alternative paths:

- **B^{ABET} + $(M/30)^{Validated}$ & E** – This is currently considered to be the primary path for BOK fulfillment. "B^{ABET}" refers to an ABET/EAC accredited baccalaureate degree in

civil engineering. "M/30" refers to a master's degree or approximately 30 semester credits of acceptable graduate-level (or upper-level undergraduate) courses in a technical or professional practice area related to civil engineering. "E" refers to engineering experience. For this path, the accreditation process provides validation of the baccalaureate component of the BOK. Validation of the "M/30" program will be provided by an approved outside entity, which might also be ABET.

- **B + M^{ABET} & E** – This secondary path is currently being explored by ASCE for fulfilling the Civil Engineering Body of Knowledge in the future. For this path, the baccalaureate degree need not be an ABET/EAC accredited degree in civil engineering. Validation of the baccalaureate and master's-level components of the BOK is accomplished through ABET/EAC accreditation of the civil engineering master's degree. ASCE is currently pursuing modifications to ABET Advanced Level General Criteria and accreditation policies, such that this secondary path becomes viable in the future.

A detailed discussion of this "two-path model" is beyond the scope of this paper. The key point of commonality between both paths is that *ABET accreditation is essential to the validation of BOK fulfillment.*

Although we have assumed that the ABET criteria constitute the only viable instrument for effecting BOK implementation, it is *not* true that the criteria are entirely adaptable to this purpose. The ABET criteria consist of three different components, each with its own unique limitations as an instrument for BOK implementation:

- The ***Basic Level General Criteria*** are applicable to *all* ABET-accredited programs in *all* engineering disciplines. Changing these criteria would require the support of ABET and its 27 member societies. In the short term, ASCE has little or no capability to gain such broad support. Thus, in the short term, we consider the ABET Basic Level General Criteria to be unchangeable.

- The ***Advanced Level General Criteria*** are also applicable to all engineering disciplines; however, because very few programs are currently accredited at the advanced level, it is at least feasible for ASCE to influence changes to these criteria. Nonetheless, such changes must still be applicable and acceptable to all engineering disciplines. Discipline-specific additions to the Advanced Level General Criteria would not be permissible.

- The ***Basic Level Program Criteria*** are applicable only to specific engineering disciplines and are established and maintained by the associated ABET member society. The Basic Level Civil Engineering Program Criteria are applicable to "civil and similarly named engineering programs" and are established by ASCE. Because ASCE has considerable authority to change these criteria, they must necessarily be the principal accreditation-related mechanism for BOK implementation.

ASCE's authority over its program criteria is not unlimited, however. All program criteria are subject to ABET approval; and in order to gain approval, proposed criteria must be appropriately outcomes-based and must not be overly prescriptive. In an era when new engineering disciplines

are constantly emerging and existing disciplinary boundaries are blurring, program criteria are viewed as an anachronism in some ABET circles. Indeed, some members of the ABET leadership favor the total elimination of program criteria. In this environment, there are significant constraints on ASCE's ability to use the Basic Level Civil Engineering Program Criteria as its principal instrument for implementation of the BOK.

In theory, Advanced Level Civil Engineering Program Criteria might also be used as an instrument for BOK implementation. In practice, however, no advanced level program criteria are currently included in the ABET Engineering Criteria, and there is little chance of gaining ABET approval for such criteria. Thus the Accreditation Committee has not considered Advanced Level Civil Engineering Program Criteria to be viable.

The ***ASCE Commentary*** is also available as an instrument for BOK implementation, although it is not (nor can it ever be) a formal part of the ABET criteria. The commentary is an internal ASCE document that provides civil engineering program evaluators with guidelines for conducting accreditation visits under the current ABET criteria—with emphasis on the Basic Level Civil Engineering Program Criteria.[6] Since the ASCE Commentary is permitted by ABET and is already well known to program evaluators and civil engineering faculty, it represents a powerful means of communication with several of the most important constituencies associated with BOK implementation. Like the Civil Engineering Program Criteria, however, the ASCE Commentary is subject to significant constraints. Most important, in order to remain acceptable to ABET, the ASCE Commentary may not supplement the ABET criteria in any way. The commentary can provide guidance on how to apply the existing criteria; however, it may not include any provision that might be interpreted as additional evaluation criteria. To emphasize its unofficial status, the ASCE Commentary is now, and will continue to be identified as, a draft document.

Formulating a Model for Criteria Development

Given this highly constrained set of accreditation-related instruments, the Accreditation Committee faced the challenge of determining which instrument would be most appropriate for fostering the implementation of each BOK outcome. Three considerations heavily influenced the committee's approach to meeting this challenge:

- The first 11 outcomes of the Civil Engineering Body of Knowledge correspond *nominally* to Criteria 3(a) through 3(k) in the ABET Basic Level General Criteria; however, the BOK describes these outcomes with a considerably greater specificity than the ABET criteria. For example, BOK Outcome 1 (an ability to apply knowledge of mathematics, science, and engineering) is nominally identical to ABET Criterion 3(a); however, the text associated with BOK Outcome 1 also calls for coverage of mathematics through differential equations, probability and statistics, calculus-based physics, biology, chemistry, ecology, geology/geomorphology, engineering economics, mechanics, material properties, systems, geo-spatial representation, and information technology. None of these subjects are specified under Criterion 3(a); thus, ABET's prohibition on supplementing the ABET General Criteria would prevent ASCE from requiring competency in these subjects under the auspices of Criterion 3(a). If any such

requirement is to be enforceable, it would have to be included in the Civil Engineering Program Criteria.

- The ABET Advanced Level General Criteria provide the only feasible means of accomplishing two distinctly different aspects of BOK implementation. First, since BOK Outcome 12—the requirement for ability in a specialized area of civil engineering—can only reasonably be accomplished at the graduate level, this requirement must be incorporated into the Advanced Level General Criteria. Second, these criteria must address the requirement for an ABET-accredited master's degree to serve as the *de facto* validation for civil engineers seeking to fulfill the BOK via the secondary path described above. To satisfy this requirement, the Advanced Level General Criteria must require satisfaction of the Basic Level General Criteria and the Basic Level Program Criteria. Without such a provision, awarding an ABET-accredited master's degree would not guarantee that the entire Civil Engineering Body of Knowledge had been fulfilled. This particular requirement represents a major challenge, because many engineering disciplines prefer not to require that master's degree recipients in their disciplines also satisfy their Basic Level Program Criteria.

- BOK Outcomes 1 through 11 are logically addressed in the basic level criteria, because of their direct association with ABET Criteria 3(a) through 3(k). BOK Outcome 12 is logically addressed in the advanced level criteria, because it requires advanced, specialized knowledge. BOK Outcomes 13 through 15, however, might reasonably be addressed at *either* the basic or advanced level. These professional practice topics—project management, construction management, asset management, business, public policy and administration, and leadership—could logically be integrated into the undergraduate civil engineering curriculum *or* offered as part of a professional practice-oriented master's program. From an accreditation perspective, however, it is *only* possible to address these topics in the Basic Level Civil Engineering Program Criteria. Addressing these professional practice topics at the graduate level would require their inclusion in the Advanced Level General Criteria—which cannot be approved without the broad support of the other engineering societies. Since these topics are, to some degree, discipline-specific, it would be virtually impossible to gain the support necessary for their approval.

In response to these considerations, the Accreditation Committee has formulated its proposed BOK-compliant ABET accreditation criteria according to the model illustrated in Figure 2 below. BOK Outcomes 1 through 11 are addressed in both the Basic Level General Criteria and the Basic Level Civil Engineering Program Criteria. Specifically, all aspects of BOK Outcomes 1 through 11 that are not addressed in the *existing* Basic Level General Criteria must be incorporated into *revised* Basic Level Civil Engineering Program Criteria. This differentiation is driven by the fact that the General Criteria cannot effectively be changed by ASCE, while the Program Criteria can. BOK Outcome 12 is addressed in a proposed revision to the Advanced Level General Criteria that is currently being considered by ABET. Outcomes 13 through 15 are addressed entirely within the Basic Level Civil Engineering Program Criteria, again primarily because these criteria are subject to ASCE's immediate control.

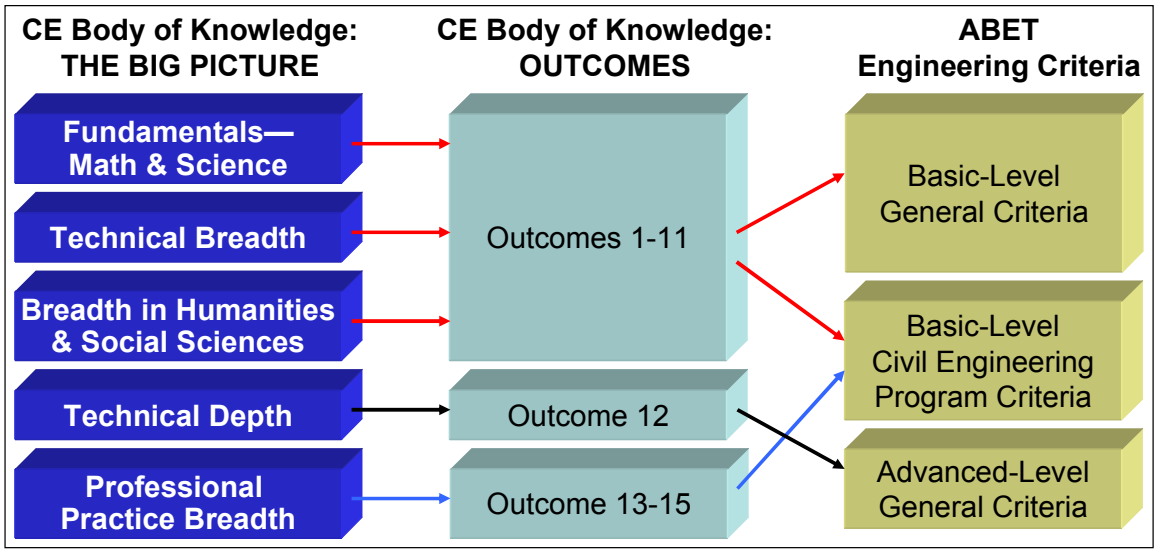

Figure 2. Association between proposed BOK-compliant accreditation criteria and BOK outcomes.

Consistent with this model, new BOK-compliant ABET Basic-Level Civil Engineering Program Criteria and Advanced Level General Criteria were drafted in the spring of 2004 and are now being shared with the broader community of civil engineering educators and practitioners. The criteria have undergone several major revisions in response to input from these constituencies, and discussions are expected to continue even after the draft Basic-Level Criteria are submitted to ABET in the spring of 2006. ASCE's goal is to fully implement these criteria for accreditation visits occurring during academic year 2008-2009.

Development of Basic Level Civil Engineering Program Criteria

The Accreditation Committee's first attempt to produce BOK-compliant Basic Level Civil Engineering Program Criteria met with mixed results. The first-draft criteria were based on a fundamental premise that *satisfaction of the criteria must also guarantee full implementation of the Civil Engineering Body of Knowledge*. This premise, though advantageous from the perspective of BOK implementation, resulted in a set of criteria that were excessively prescriptive. Upon reviewing the draft, many civil engineering department heads expressed strong opposition, and ASCE's representatives on the Engineering Accreditation Commission suggested that the criteria were too prescriptive to be approved by ABET.

On the positive side, the circulation of highly prescriptive draft Civil Engineering Program Criteria got the attention of many constituents who, until that time, had demonstrated only a passing interest in Policy Statement 465 and the BOK. The draft also called attention to several previously misunderstood aspects of the BOK—most notably the fact that BOK Outcomes 1 through 11 do not corresponded exactly to ABET Criteria 3(a) through 3(k).

Before developing a second draft of the Basic Level Civil Engineering Program Criteria, the Accreditation Committee needed to reevaluate its concept of BOK-compliance. Rather than ensuring that satisfaction of the criteria would also guarantee full implementation of the BOK, the Accreditation Committee established two new fundamental premises:

- The criteria represent only a *minimum standard* for fulfillment of the Civil Engineering Body of Knowledge.

- Programs that aspire to full, robust implementation of the BOK will need to do considerably more, on a voluntary basis, than the criteria prescribe.

This revised concept of BOK-compliance strikes a more realistic balance between fostering full implementation of the BOK and preserving curricular flexibility. The premise that criteria represent only a minimum standard resulted in a revised set of draft Civil Engineering Program Criteria that were markedly less prescriptive than the original version. As a result, this new draft won significant support from department heads; nonetheless, it subsequently proved to be problematic from the perspective of curricular design and assessment.

Consistent with *Civil Engineering Body of Knowledge for the 21st Century,* these second-draft criteria used the terms *recognition, understanding,* and *ability* to describe three specific levels of competence (later renamed *levels of achievement*). Well-defined levels of achievement are essential to the concept of BOK fulfillment as a three-stage progression from undergraduate education to graduate education to engineering practice. For each BOK outcome, an expected level of achievement can be identified for each of these stages, thus clearly defining the developmental progression and providing the basis for both curricular design and assessment.

Unfortunately, the terms *recognition, understanding,* and *ability* proved to be inadequate as levels of achievement. The Curriculum Design Committee of CAP^3, charged with developing model BOK-compliant civil engineering curricula, found that these terms were too ambiguous to be usable. With no shared understanding of what the terms meant, committee members interpreted *recognition, understanding,* and *ability* in widely different ways, resulting in significant inconsistencies in their model curricula.

CAP^3 solved the problem by abandoning *recognition, understanding,* and *ability* as levels of achievement and adopting Bloom's Taxonomy in their place.[7] Bloom's Taxonomy is a well-established framework for defining educational objectives in terms of the desired level of cognitive development.[8] Bloom's six levels of cognitive development—knowledge, comprehension, application, analysis, synthesis, and evaluation—describe a hierarchy of increasing complexity and sophistication in thought. Definitions of the six levels are provided in the center column of Table 1.

The fundamental premise of Bloom's Taxonomy is that an educational objective can be referenced to a specific level of cognitive development through the verb used in the objective statement. Some illustrative examples of verbs associated with Bloom's six levels are provided in the right-hand column of Table 1.

CAP^3 has now adopted Bloom's six levels of cognitive development, without modification, as levels of achievement. Consequently, the Accreditation Committee of CAP^3 has developed yet another set of draft Basic Level Civil Engineering Program Criteria, in which the verbs used in each provision imply specific levels of achievement that must be demonstrated for compliance with the criteria. The adoption of Bloom's Taxonomy has won strong support from the

Curriculum Design Committee, in part because the use of strong, action-oriented verbs has significantly improved the clarity, conciseness, and measurability of these draft criteria.

Level	Definition	Illustrative Verbs
1. Knowledge	The remembering of previously learned material. This may involve the recall of a wide range of material, from specific facts to complete theories, but all that is required is the bringing to mind of the appropriate information.	define; describe; enumerate; identify; label; list; match; select; state.
2. Comprehension	The ability to grasp the meaning of material. This may be shown by translating material from one form to another (words to numbers), by interpreting material (explaining or summarizing), and by estimating future trends (predicting consequences or effects). These learning outcomes go one step beyond simple remembering and represent the lowest level of understanding.	classify; cite; convert; describe; discuss; explain; generalize; give examples; paraphrase; summarize.
3. Application	The ability to use learned material in new and concrete situations. This may include the application of rules, methods, concepts, principles, laws, and theories. Learning outcomes in this area require a higher level of understanding than those under comprehension.	apply; calculate; chart; compute; determine; demonstrate; implement; relate; report; solve; use.
4. Analysis	The ability to break down material into its component parts so that its organizational structure may be understood. This may include the identification of parts, analysis of the relationship between parts, and recognition of the organizational principles involved. Analysis represents a higher level than comprehension and application because it requires an understanding of both the content and the structural form of the material.	analyze; correlate; differentiate; discriminate; distinguish; formulate; illustrate; infer; organize, outline; prioritize; subdivide.
5. Synthesis	The ability to put parts together to form a new whole. This may involve the production of a unique communication, a plan of operations (research proposal), or a set of abstract relations (scheme for classifying information). Learning outcomes in this area stress creative behaviors, with major emphasis on the formulation of new patterns or structure.	adapt; combine; compile; compose; create; design; develop; devise; generate; integrate; modify; plan; revise; structure.
6. Evaluation	The ability to judge the value of material for a given purpose, based on definite criteria. Learning outcomes in this area are highest in the hierarchy because they contain elements of all the other categories, plus conscious value judgments based on clearly defined criteria.	appraise; compare & contrast; conclude; criticize; critique; decide; defend; evaluate; judge; justify.

Table 1. Bloom's Taxonomy.

Basic Level Civil Engineering Program Criteria

As a result of the two-year collaborative developmental process described above, the Accreditation Committee has formulated the following draft Basic Level Civil Engineering Program Criteria:

1. Curriculum

The program must demonstrate that graduates can apply knowledge of mathematics through differential equations, calculus-based physics, chemistry, can apply knowledge of four technical areas appropriate to civil engineering; can conduct civil engineering experiments and analyze and interpret the resulting data; can design a system, component, or process in more than one civil engineering context; and can explain the fundamentals of management, business, public policy, and leadership.

2. Faculty

The program must demonstrate that faculty teaching courses that are primarily design in content are qualified to teach the subject matter by virtue of professional licensure, or by education and design experience. The program must demonstrate that it is not critically dependent on one individual.

These new draft criteria are best understood through a direct comparison with the current Civil Engineering Program Criteria, published in November 2004.[3] A line-by-line comparison is provided in Table 2 below. In this table, the current and proposed criteria have been dissected into specific provisions, designated A through F for ease of reference.

The proposed BOK-compliant Basic Level Civil Engineering Program Criteria differ from the current criteria as follows:

Provision A. The proposed criteria continue to recognize mathematics through differential equations, calculus-based physics, and chemistry as integral to the "technical core" of civil engineering. Consistent with Bloom's Taxonomy, the verb *apply* implies that the expected level of achievement is Level 3, Application. To comply with this provision, a program would be expected to demonstrate that its graduates can apply math and science concepts and principles to solve relatively straightforward problems. In the interest of reducing prescriptiveness, the requirement for probability and statistics has been dropped in the new criteria. Because applications of probability and statistics are prevalent in civil engineering, and because many civil engineering subjects (e.g., hydrology and structural reliability) cannot be taught adequately without probability and statistics, it is expected that most programs will continue to offer this subject to their students.

Provision	Current Criteria	Proposed BOK-Compliant Criteria
	The program must demonstrate that graduates have	The program must demonstrate that graduates
A	proficiency in mathematics through differential equations, probability and statistics, calculus-based physics, and general chemistry;	can apply knowledge of mathematics through differential equations, calculus-based physics, chemistry, ...
B		...and at least one additional area of science, consistent with the program educational objectives;
C	proficiency in a minimum of four recognized major civil engineering areas;	can apply knowledge of four technical areas appropriate to civil engineering;
D	the ability to conduct laboratory experiments and to critically analyze and interpret data in more than one of the recognized major civil engineering areas;	can conduct civil engineering experiments and analyze and interpret the resulting data;
E	the ability to perform civil engineering design by means of design experiences integrated throughout the professional component of the curriculum;	can design a system, component, or process in more than one civil engineering context;
F	and an understanding of professional practice issues such as: procurement of work, bidding versus quality-based selection processes, how the design professionals and the construction professions interact to construct a project, the importance of professional licensure and continuing education, and/or other professional practice issues.	and can explain the fundamentals of management, business, public policy, and leadership.

Table 2. Comparison of current and proposed Basic Level Civil Engineering Program Criteria

Provision B. The requirement that graduates are able to apply one additional area of science is found only in the new criteria and reflects the BOK's emphasis on fundamentals and on technical breadth. The BOK is actually much more prescriptive in its requirement for specific science subjects, such as biology, ecology, geology, geomorphology, and geo-spatial representation. By leaving the choice of additional science coverage to the program (consistent with the program objectives), the new criteria provide curricular flexibility, while still clearly communicating the intent of the BOK.

Provision C. The proposed criteria retain the requirement for coverage of four civil engineering technical areas—a clear statement that civil engineering technical breadth remains essential to the BOK. However, the current requirement for *proficiency* in four areas has been replaced with the verb *apply*, again reflecting Level 3, Application, as the expected level of achievement. This

change will eliminate the longstanding confusion and disagreement that has often accompanied the term *proficiency*, while also setting a more realistic standard of achievement in undergraduate civil engineering technical areas. At first glance, the change from *proficiency* to *application* might appear to be a "lowering of the bar" for civil engineering education. From a broader perspective, however, the change actually represents a reallocation, rather than a reduction. Specifically, technical depth is reallocated from the undergraduate level to the graduate level—as reflected in the proposed Advanced Level General Criteria, discussed below—and professional practice breadth is given correspondingly greater emphasis in the undergraduate curriculum.

Finally, it should be noted that the phrase "technical areas appropriate to civil engineering" is specifically intended to provide programs with greater flexibility in defining curricular content. Under the new criteria, non-traditional and emerging engineering subjects could be defined as "technical areas appropriate to civil engineering," even though they probably would not have qualified as "recognized major civil engineering areas" under the current criteria.

Provision D. Consistent with Bloom's Taxonomy, the verb *conduct* in this provision implies that the level of achievement for such tasks as experimental setup, measurement, and data collection is Level 3, Application. The verbs *analyze* and *interpret* imply that the level of achievement for processing experimental data is Level 4, Analysis. Under the proposed criteria, programs need only demonstrate that their graduates can conduct experiments in one civil engineering technical area, rather than the two areas specified in the current criteria. This change was made for consistency with the BOK and to provide programs with greater curricular flexibility; nonetheless, it is highly unlikely that bona fide Level 4 ability to analyze and interpret experimental data could be developed through a single civil engineering laboratory experience. It is also important to recognize that the requirement for graduates' ability to design experiments—a Level 5 (Synthesis) activity—remains in Criterion 3(b) of the Basic Level General Criteria.

Provision E. The proposed criteria have been made less prescriptive and more outcomes-based through the elimination of the requirement for "ability to perform civil engineering design by means of design experiences integrated throughout the professional component of the curriculum." The new reference to "more than one civil engineering context" is intended to ensure that students can perform design in at least two civil engineering contexts that are significantly different from each other. One unambiguous way to satisfy this criterion would be for the curriculum to include required design experiences in more than one civil engineering technical area. For example, a program that requires its students to design both a reinforced concrete building frame (a structural engineering context) and a deep foundation (a geotechnical engineering context) would be in compliance. Conversely, a program that requires its students to design only a reinforced concrete structure and a steel structure would not be in compliance, since the design process for steel and concrete structures is so similar. This provision communicates the BOK's emphasis on breadth of the engineering design experience without prescribing how that breadth must be achieved.

The verb *design* in this provision implies that the expected level of achievement is Level 5, Synthesis. Consistent with Bloom's definition of synthesis, student design experiences should involve creative effort that combines various elements into a new whole. These experiences

should also reflect the characteristics of the engineering design process specified in Criterion 4 of the Basic Level General Criteria.

Provision F. Although the professional practice-related provisions of the new criteria are considerably shorter than those of the current criteria, the required subject areas—management, business, public policy, and leadership principles—are much broader. This change reflects the BOK's increased emphasis on professional practice breadth. The BOK actually defines these subjects with considerably greater specificity—project management, construction, asset management, business fundamentals, public policy, public administration, leadership principles, and attitudes—but the criteria use more general terminology to promote flexibility.

It is also noteworthy that, through the use of the verb *explain*, the proposed criteria require only Level 2, Comprehension, as the level of achievement for the professional practice topics.

Advanced Level General Criteria

The Accreditation Committee of CAP[3] has proposed the following draft Advanced level General Criteria to ABET:

> Advanced Level Programs must develop, publish, and periodically review educational objectives and program outcomes. The program must demonstrate that graduates attain, through their educational and professional experiences, knowledge and skills consistent with fulfillment of the basic level general criteria and applicable program criteria (if any). Advanced level programs must consist of at least one academic year of study beyond the basic level. Graduates must have a culminating engineering experience demonstrating advanced level program knowledge.

Much of the wording in this proposed draft is not related to BOK implementation, having been put forward by constituencies other than ASCE. However, as noted above, two key provisions of these criteria are essential for BOK implementation:

- As specified in BOK Outcome 12, the criteria require advanced-level technical specialization (identified as "advanced level program knowledge" in the criteria).

- The criteria stipulate that graduates of accredited master's programs fulfill both the Basic Level General Criteria and the Basic Level Program Criteria applicable to the discipline. This provision is necessary, if the accreditation process is to serve as the mechanism for validation of BOK fulfillment, as specified in the **B+M^{ABET}&E** path described above.

Beyond these minimum essential BOK-related provisions, ASCE prefers that the Advanced Level General Criteria *not* include additional requirements for culminating projects, communications skills, supplemental assessment processes, etc. Such provisions do little to advance BOK fulfillment, are often redundant with basic-level criteria, and are frequently viewed as being overly prescriptive. The most likely outcome of such stringent requirements is to provide an incentive for programs to avoid seeking advanced-level accreditation.

The Draft ASCE Commentary

For nearly a decade, the draft ASCE Commentary has served the accreditation process effectively by providing practical guidelines for ABET civil engineering program evaluators to apply the ABET criteria in a fair and consistent manner. The commentary has served civil engineering faculty equally well, by providing insights about the criteria and the evaluation process from an evaluator's perspective. With the advent of the BOK, a new draft ASCE Commentary will continue to serve these purposes but will also be used for one additional function—providing guidelines to close the gap between satisfaction of the ABET criteria and fulfillment of the BOK.

As discussed above, the proposed criteria represent only a *minimum standard* for fulfillment of the BOK; programs that aspire to full, robust implementation of the BOK must voluntarily do more than the criteria prescribe. The new draft ASCE Commentary provides recommendations for specific voluntary measures that will ensure full, robust BOK implementation.

This document is organized in terms of the 15 BOK Outcomes, emphasizing that the BOK is the foundation upon which civil engineering accreditation is built. For each outcome, the following are provided:

- A brief rationale for the outcome;
- The specific ABET criteria representing the minimum standard for fulfillment of the outcome;
- Commentary on these criteria; and
- Recommended measures that exceed the criteria but are required to ensure full, robust implementation of the BOK.

The commentaries on each outcome are intended primarily for civil engineering program evaluators, although they will also be of considerable interest to civil engineering faculty. The recommended measures to ensure full BOK implementation are intended solely for faculty. These measures exceed the criteria and thus, by definition, may not be enforced by program evaluators.

The new draft ASCE Commentary is currently under internal review by the Accreditation Committee. Upon completion of this review, it will be posted on the ASCE Policy Statement 465 website (http://www.asce.org/raisethebar/) for public review and comment.

Conclusion

The ASCE Civil Engineering Body of Knowledge describes the knowledge, skills, and attitudes necessary for entry into the practice of civil engineering at the professional level. The BOK is defined in terms of fifteen outcomes, which reflect the following major areas of emphasis:

- Fundamentals of math, science, and engineering science
- Technical breadth

- Breadth in the humanities and social sciences
- Technical depth
- Professional practice breadth

The Accreditation Committee of CAP[3] has developed a set of draft ABET accreditation criteria that establish a minimum standard for BOK implementation in these areas. The proposed Basic Level Civil Engineering Program Criteria emphasize fundamentals by requiring graduates' understanding of an additional area of science beyond the traditional civil engineering technical core of math, physics, and chemistry. This same provision also provides increased technical breadth, while another preserves the longstanding requirement for coverage of four civil engineering areas. The proposed Basic Level Civil Engineering Program Criteria significantly increase professional practice breadth through a provision requiring that graduates can explain the fundamentals of management, business, public policy, and leadership principles. Breadth in the humanities and social sciences is emphasized through Criterion 3 of the Basic Level General Criteria. And finally, ASCE's proposed Advanced Level General Criteria provide for increased technical depth through a requirement for graduate-level knowledge in a specialized area of civil engineering.

Although these new criteria reflect the five BOK areas of emphasis, they are not sufficiently specific to ensure full, robust BOK implementation. Our unsuccessful early attempts at criteria development demonstrated conclusively that fully BOK-compliant criteria are neither acceptable to several important constituencies nor suitable for approval by ABET. As a result, we have developed criteria representing only the *minimum standard* for BOK implementation—and we have used the ASCE Commentary to recommend additional measures that exceed the criteria but are necessary for full, robust BOK implementation.

The proposed Basic Level Civil Engineering Program Criteria will be submitted to ABET in the spring of 2006. Even after submission to ABET, however, they are subject to discussion and modification during the ABET public review period. This paper represents one component of a broader campaign to continue the ongoing dialog about these criteria with the civil engineering education, professional practice, and accreditation communities. Readers who wish to provide comments and recommendations about any of these products are strongly encouraged to do so by contacting the author at stephen.ressler@usma.edu.

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